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ABSTRACT

Three studies of five seventh-grade students (ages 12-14) with emotional disturbances were conducted to determine whether a stimulus class would emerge as a result of one conditional discrimination training using direct instruction (implemented with a constant time delay) augmented with instructive feedback. The students were taught to identify fractions and their equivalents in lowest form and multiplied by factors. Each of the three experiments are described. The results indicate that, after modifications in the placement of the lowest form of the fraction, the students were able to form a stimulus class. This was accomplished with minimal number of trials and training time, near errorless learning, and in a classroom setting with group instruction. Factors that affected the results are discussed, including students' history or experience with the procedure. Further research is urged to merge the phenomenon of stimulus equivalence and direct classroom instruction. Charts illustrating each student's acquisition percentage are included. (Contains 24 references.) (CR)

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Stimulus Equivalence Established Through Instructive Feedback

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Abstract

Three studies were conducted to determine whether a stimulus class would emerge as a result of one conditional discrimination training (implemented with constant time delay) augmented with instructive feedback. Five middle school-aged students enrolled in a class for emotional support participated in the studies. The students were taught to identify fractions and their equivalents in lowest form and multiplied by factors. The results indicated that, after modifications in the placement of the lowest form of the fraction, the students were able to form a stimulus class. This was accomplished with minimal number of trials and training time, near errorless learning, and in a classroom setting with group instruction. Repeated probing strengthened the relationships.

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Stimulus Equivalence Established Through Instructive Feedback

An equivalence class of three or more stimuli can be formed by training all the relationships contained within the class. However, many investigators have found that not all the relationships in a class need to be trained for an equivalence class to emerge (Sidman, 1971, Sidman & Tailby, 1982; Fields, Verhave, & Fath, 1984; Spradlin, Cotter, & Baxley, 1973). For example, if A=B and B=C, then subjects may be able to identify C as an equivalent stimulus if they are shown A. Furthermore, if a strong stimulus class has been formed through training A=B and B=C, then subjects will be able to identify A if C is presented, to identify B if A is presented, and to identify B if C is presented.

Training to establish such a stimulus class typically consists of training pairs of stimuli using a conventional match-to-sample procedure training at least two classes of stimuli concurrently (Fields & Verhave, 1987), and using unidirectional training (O'Mara, 1991). Testing which follows the training uses a match-to-sample format to present the training stimuli in pairs that were never seen together in training and that were seen in another order. To be accepted as a stimulus class, the subject must show three conditions (Sidman & Tailby, 1982): (a) reflexivity--the ability to match each stimulus to itself without prior instruction; (b) symmetry--the ability to match pairs that have been trained in reverse temporal order; and (c) transitivity--the ability to identify a third conditional relation between the sample of the first relation and the correct comparison of the second. This must emerge without reinforcement or other training or instructions (Harrison & Green, 1990).

Training to form stimulus classes has generally been conducted in a train-test-train-test paradigm with conditional discrimination training given individually. The subject acquires the relationships through interactions with a teaching machine (Spradlin et al., 1973), a computer (Fields, Adams, Verhave, & Newman, 1990), or a teacher (Osborne & Gatch, 1989). The training in such experimental studies has been conducted on an individual basis. No studies were found in which the training was conducted in a group.

Theoretically, the minimal conditions needed to link all stimuli within a class is the establishment of (n-1) two term relations by direct training, providing each element in the class is used once (Fields et al., 1984). O'Mara (1991) concurs, stating that the number of "links" (conditional relations) required is n-1, otherwise, one of the stimuli will be omitted.

Several studies of direct instruction with learners who have disabilities have focused on a procedure called instructive feedback (Gast, Ault, Wolery, Doyle, & Baklarz, 1991; Wolery, Cybriwsky, Gast, & Boyle-Gast, 1991; Wolery, Doyle, et al., 1991; Wolery, Holcombe, Werts, & Cipolloni, in press). In these studies, trials are operationalized as follows: The teacher secures the student's attention, presents the target stimulus and task direction (i.e., often "What is this?"), and provides a response interval. If the student responds correctly, the teacher praises or otherwise reinforces the child and simultaneously presents a second stimulus (i.e., instructive feedback). The student is not expected to respond to this second stimulus and is not reinforced for doing so. For example, the student is taught to read a printed word, and during the delivery of the consequent events for correct responses the definition of the word is supplied (i.e., instructive feedback).

When this arrangement is used, students acquire the target relation (e.g., reading the

word) and often acquire some if not all the relations presented through instructive feedback (e.g., they are able to state the definition of the word). Wolery, Werts, Holcombe, Billings, and Vassilaros (in press) investigated the possibility that students would acquire two pieces of information presented as instructive feedback. They taught children to name the values of various arrays of coins, and through instructive feedback, presented the corresponding numeral and corresponding number word. They compared two conditions: presentation of the corresponding numeral and corresponding number word on all trials through instructive feedback (called simultaneous condition), and presentation of the corresponding numeral on half the trials and the corresponding number word on the other half of the trials through instructive feedback (called alternating condition). The results indicted that no substantial differences occurred in the amount of instructive feedback information learned. Students were able to match the target stimulus to the corresponding numerals and number words for both the simultaneous and alternating conditions. The instructive feedback stimuli in the alternating condition had never been seen together during instruction. However, tests for reflexivity, symmetry, and transitivity were not conducted; therefore, no definitive statements could be made about the formation of stimulus classes. However, the students' ability to match the instructive feedback stimuli from the alternating condition raised the question of whether stimulus classes could be established through instructive feedback.

Thus, the focus of this experiment was to determine whether stimulus equivalence or the formation of an equivalence class could be established in one training series by using instructive feedback: conducting target training with direct instruction on only one relationship while presenting two other relationships via instructive feedback. Additionally, the training was conducted in a group situation in a classroom. The testing on all relationships was conducted for each student prior to training and after the students reached the criterion level on the target behavior. Testing was kept to a minimum to counteract the effect of emergence of stimulus classes or stimulus equivalence during testing so that we could determine whether instructive feedback training was the agent for establishing equivalence.

Experiment I

Methods

Subjects

Five subjects enrolled in a suburban middle school served as subjects. They were enrolled in seventh grade and were receiving special education services in a classroom for emotional support. All five were diagnosed as Socially and Emotionally Disturbed. All were caucasian and were from middle income homes. Four of the five were from single-parent homes.

Three of the five subjects had a deficit area in Arithmetic on the Wide Range Achievement Test (WRAT) (Jastak & Wilkinson, 1984), 6th percentile for Emma and Ken and 12th percentile for Teddy. Drew scored a scaled score of 7 in arithmetic on the Wechsler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974). Barry was at grade level for all academic subjects. In the language arts areas, three students, Emma, Teddy and Ken, scored at average or better on the WRAT. Drew was given the Peabody

Individual Achievement Test-Revised (Dunn & Markwardt, 1988), and scored in the average range in reading comprehension. Demographic information on subjects is shown in Table 1.

Insert Table 1 about here

Setting

Instructional sessions were conducted by the special education teacher in the classroom (5.6 m x 8.5 m). Typically, two to three other students were also in the room and receiving instruction from a classroom assistant during the experimental sessions. The training sessions and the probe sessions took place at a table (1.5 m x 1 m) at the front of the classroom. Students sat facing the teacher with their backs to the classroom. Probe sessions also were conducted by the teacher at the same table and were conducted individually.

Materials

Fractions printed in black numerals (Universal type, 36 point) on white cards (7 cm x 13 cm) were used for instruction. The target stimuli were fractions that were not in lowest form and the instructive feedback stimuli, printed on the back of the card in the same type were equivalent, but different forms, of those fractions. These stimuli are shown in Table 2.

Insert Table 2 about here

Four fractions printed in black, 36 point Universal type on a standard sheet of white paper (21.5 cm x 28 cm) were displayed in the four quadrants of the paper presented horizontally. The four choices consisted of the correct answer (B1), the equivalent fraction for the other target in the training (B2), a fraction consisting of the numerator of B1 and the denominator of B2, and fraction consisting of the numerator of B2 and the denominator of B1. In the two cases that this resulted in a distractor fraction equaling 1, the digits of the denominators were reversed, resulting in the use of all digits in the fractions an equal number of times equating the positive and negative valences of the choices. One sheet of fractions was used for 5 trials and then a new sheet with the fractions in different positions was placed on the table in front of the students. If there was only one student in the group. The sheet was rotated after two trials. Session duration was timed with a stopwatch.

Materials used in the probe sessions were similar to those used in training. The stimulus cards had a fraction on only one side of each card, either A1, B1, C1, or D1. Students pointed to their choices on sheets of paper with four fractions arrayed and selected in the same manner as those for the training sessions. The probe sessions included fractions from all three planned experiments.

Reinforcers were used in each training session. For the first two training sessions, small crackers were used. At the request of the students, the reinforcer was changed to gum. This was used for the remainder of the sessions through all three experiments.

Procedures

General procedures. Initially, all students were screened to identify unknown stimuli. Six sets of 4 equivalent fractions were identified as behaviors for instruction and were assigned to each experiment. Following identification of fractions, pretest measures were implemented. Tests for reflexivity were given prior to the first training. Symmetry and transitive relationships were intermixed and tested over three days. Three target probes were administered during the same three day period but in separate sessions. Instruction began for Experiment I when all children finished probe sessions. One training session was conducted daily, generally five days per week. Two target stimuli were taught in the sessions. All five students were taught the same stimuli using a constant time delay technique with instructive feedback.

Probe condition procedures. Probes to evaluate reflexivity (Sidman & Tailby, 1982) were conducted individually by showing the students a fraction on a card (7 cm x 13 cm), and simultaneously displaying an array of six fractions, with one of the 6 being identical to the sample, on an sheet of paper (21.5 cm x 28 cm). The papers were clipped into a three ring binder. One page was used per trial. All the fractions to be used in the three experiments were evaluated in one session with one presentation each of the 24 fractions that were originally identified for instruction.

A target check probe was implemented after training was completed and prior to full probing. Four trials (2 per stimuli in the training set) using just the target behaviors (A1=B1 and A2=B2) were given individually to the student. If the performance was at 100% correct responding, the full probes were implemented.

Individual full probe sessions were conducted to evaluate acquisition of target behaviors (A=B relationships), behaviors presented in instructive feedback (B=C, and B=D), and the relationships expected due to symmetry (B=A, C=B, D=B, D=C, C=A, and D=A) and transitivity (C=D, A=C, A=D). These took place prior to training, and following each experiment. Instructive feedback, symmetry, and transitive probe sessions were conducted over three days and included 1 trial for each behavior per relationship in other experiments (44 trials) and 3 trials for each behavior in the currently trained set (66 trials). One trial per target relationship was given in each probe session. Three target probe sessions were given for a total of 72 target trials (24 for each experimental set).

The notebook containing the sheets of comparison stimuli was placed on the table in front of the subject. Each trial began with the presentation of a fraction on the stimulus card (7 cm x 13 cm). The teacher held the card so that it could be seen, gave an attending cue, ("Look" or "Ready?" or said the name of the student), and then gave the task direction, "What fraction is equal to this fraction?" The subject was given 3 seconds to respond and was instructed to "Guess if you don't know." The subject responded by pointing to the choice. Non-committal feedback was given intermittently. During the intertrial interval, the subject's choice was recorded by the teacher, the next sheet of comparison stimuli was shown and the next card presented.

Instructional procedures. Constant time delay was used to teach the equivalent fractions A1 = B1 and A2 = B2 for Experiment I (shown in Table 2). Following a correct

response either before or after the controlling prompt, the C stimuli were shown on half the trials and the D stimuli on the other half (i.e., for A1=B1 half the trials resulted in the presentation of C1 and the other half with D1; for A2=B2 half resulted in the presentation of C2 and half with the presentation of D2). The experiment is diagrammed in Figure 1.

Insert Figure 1 about here

In a 20 trial session, each subject was given 4 trials, (2 with A1 = B1 and 2 with A2 = B2) and saw C1, C2, D1, and D2 in the instructive feedback. Order of trial presentation was random. Each instructive feedback stimuli was presented once to each subject in each session. In addition, each subject had the opportunity to observe the responses to target stimuli and the instructive feedback for the 16 additional trials presented to the other subjects in the group. As a student reached criterion level responding and was placed into probe conditions or if a student was absent, the number of trials for the group decreased by four trials. Attention to trials presented to the other students was neither required nor reinforced, and no data on attending behavior were collected.

Constant time delay includes two types of trials: 0-second and delay trials. The 0-second trials involve presentation of the task direction immediately followed by a controlling prompt (i.e., one that will ensure that the child responds correctly). In this study, the teacher provided the four choices of fractions for the response, ensured that the student was attending, presented the sample card and the task direction ("What is the lowest form of this fraction?), and immediately followed the question by pointing to the correct response choice and providing a verbal model. The student then imitated both the pointing to the correct choice and the verbal response. If a student did not point but gave the verbal response only, the teacher gave the instructions to point. If the student pointed to the correct choice but omitted the verbal model, no correction was given. The pointing response was scored in the event of a difference in verbal and pointing response. If the student responded correctly to the target trial, the teacher praised the student and delivered the reinforcer. The teacher then turned the sample card around, showing the back of the stimuli card and said, "This also equals that fraction." No response was required from the student and no consequence was attached to the instructive feedback. Since the "A" stimulus was on one side of the stimulus card and the "C" or "D" on the other side, these stimuli were not seen together.

Beginning with the second session, <u>delay trials</u> (3 seconds) were introduced. The delay trials were identical to the 0-second trials with two exceptions. First, a 3-second response interval was inserted after the task direction and before the controlling prompt. Second, at the beginning of the session, the teacher said, "If you know the answer, point to the correct choice. If you do not know, wait, and I will show you." Consequences for correct responses were identical to those for the 0-second trials. If there was no response during the response interval, the teacher modeled the correct response and allowed the student to imitate. If there was an error, the trial was terminated. Instructive feedback (turning the sample card around and showing an equivalent fraction) was presented only on the trials that elicited a correct response before or after delivery of the controlling prompt. Error responses were neither rewarded nor followed by instructive feedback.

Response definition. Five responses were possible. The students could (a) point to the correct choice (positive comparison) before the prompt--correct anticipations, (b) point to the correct choice (positive comparison) after the prompt--correct waits, (c) point to a negative comparison before the prompt--unprompted errors or incorrect anticipations, (d) point to a negative comparison after the prompt--prompted errors, or (e) give no response after the model. Training was considered to be at criterion when the students had 100% correct anticipations for six sessions--two sessions at continuous reinforcement, two with a FR2 schedule, and two with a VR4 schedule.

Reliability

Inter-observer agreement assessments occurred during probe and instructional conditions. An independent observer recorded students' responses and this record was compared to the data recorded by the teacher.

In addition, the observer recorded compliance of the teacher with the planned experimental procedures (i.e., procedural reliability) in the probe and instructional conditions (Billingsley, White, & Munson, 1980). The following instructor behaviors for the probe conditions were assessed for procedural reliability: ensuring student attention, presenting the correct stimulus, giving task directions, waiting the appropriate response interval, delivering non-committal feedback, and waiting the correct intertrial interval. The following behaviors for the instructional sessions were assessed for procedural reliability: ensuring student attention, presenting the correct stimulus, providing the task direction, waiting the appropriate response interval, delivering the prompt, providing the correct instructive feedback stimulus, and waiting the correct intertrial interval.

Results

Reliability

For student responses, the percentages of interobserver agreement were calculated using the point-by-point method (number of exact agreements divided by the number of exact agreements plus the number of disagreements and the quotient was multiplied by 100). For probe conditions, interobserver agreement was assessed on 15.5% of the sessions, and in all cases was 100%. In the instructional condition, interobserver agreement was based on 46.1%, and in all cases was 100%.

Procedural reliability was assessed on 15.5% of the probe sessions and 46.1% of the instructional sessions. Procedural reliability was calculated by dividing the number of actual teacher behaviors in each category by the number of planned behaviors and multiplying by 100 (Billingsley et al., 1980). During probes, the procedural reliability on all aspects of the procedure was at 100%. During instruction, the mean percentage of agreement on procedural fidelity was 100% on all aspects of the technique except for the following: giving praise/ignoring errors (95.8%; range 75-100%), and waiting the correct intertrial interval (98%; range 94-100%).

Reflexivity. Testing for equivalence consisted of tests for reflexivity, symmetry, and transitivity (Sidman & Tailby, 1982). Reflexive tests for all 24 fractions to be used in the

three experiments were given prior to the onset of Experiment I. All five students had 100% correct performance on these tests.

Acquisition of target relation. The constant time delay procedure was effective in teaching all five students the target relations--pointing to the lowest form of a fraction when shown an equivalent fraction that was not in its lowest form. Performance on target behavior (A = B) in target check conditions (4 individually delivered trials) was 100% for all five students. In full probe conditions with all stimuli for all three experiments intermixed, following instruction on the sets of fractions in Experiment I, was at 100% for Ken and Barry, at 95.8% for Emma and Teddy, and at 91.6% for Drew. The number of sessions through criterion, the number of minutes of instruction, and the percent of errors during training are shown in Table 3. In this experiment, students had low error rates (0% to 9%) and they reached criterion in relatively few trials (32-48). Of these trials, 24 for each student were in sessions in which there were 100% correct anticipations.

Insert Table 3 about here

Acquisition of instructive feedback relations. Acquisition of the two behaviors for each target stimulus that were presented in instructive feedback (B=C and B=D) is shown in Figure 2. Four students showed an increase in correct responding from the pre-training probes to the post-training probes. One student, Drew, showed no change for either stimuli in either class. No student had 100% correct responding for these relationships.

Insert Figure 2 about here

Symmetry and transitivity. Performance during probes on the relationships that would show symmetry and transitivity also is shown in Figure 2. No student performed at 100% in all conditions. Emma and Drew each had 100% performance on one symmetry relationship to instructive feedback. All students showed some increase in performance on symmetry and transitivity trials but many were not above what could be considered chance levels.

Discussion

The purpose of this experiment was to determine whether a 4-member stimulus class would be formed by training A=B and alternating presentation of C and D in instructive feedback.

Due to the small number of probe trials per behavior (3 per behavior yielding 6 per relationship for the two stimulus classes), a criterion of nearly 100% correct responding was necessary to conclude that an equivalence class had emerged. The students showed a general increase in correct responding, but the control was neither strong nor consistent.

At least four factors, separately or in combination, may have influenced the subjects' failure to show equivalence. First, a limited number of trials and the limited number of

exposures to the instructive feedback behaviors occurred. Fields et al. (1990) deduced that the degree of control exerted may be a derivative of the number of presentations that occurred. Second, the acquisition of the behaviors shown in instructive feedback was low. Other studies have shown that although instructive feedback can be effective, the acquisition is not always at 100% (Werts, Wolery, & Holcombe, 1991). Third, the subjects were naive. They may show greater acquisition when they have more experience with the experimental procedures. Fourth, it has been shown that testing may be an integral part of the learning process and our testing procedures were minimal, delivering only a few trials per behavior. Fields et al. (1990) stated that control was weaker at the beginning of the testing sessions and it became stronger as testing progressed. The subjects may not have had an opportunity to strengthen their responses during the testing phase of the procedure. To counteract some of these difficulties, Experiment II was initiated.

Experiment II

In this experiment, the constant time delay procedure with instructive feedback was used with the same subjects and similar stimuli (i.e., fractions). Thus, students had a history with the testing and instructional procedures. In addition, the number of stimuli presented through instructive feedback for each target behavior was reduced from two in Experiment I to one in Experiment II. Thus, each sample fraction, shown to each student in the daily instructional sessions, was linked to a single fraction shown in instructive feedback. This arrangement doubled the number of exposures to each instructive feedback stimulus but the number of exposures to each subject was still low (2 per instructive feedback stimulus per session). The specific question asked in Experiment II was: Would equivalence classes emerge from one training series using constant time delay with instructive feedback (i.e., conducting target training on only one relationship and introducing another relationship via instructive feedback)?

Methods

Subjects and Setting

The subjects and setting for Experiment II were the same as those used in Experiment I.

Materials

The materials differed only from those in Experiment I in the content of the fractions taught and the number of different instructive feedback stimuli used. The stimuli are shown in Table 2. Probe materials reflected the addition of 1 trial per behavior for Experiment II to give an equal number of pretraining trials as were used for Experiment I behaviors. Reinforcers remained the same.

Instructional Procedures.

Constant time delay was used to teach the fractions A1 = B1 and A2 = B2 in Set II (shown in Table 2). Following a correct response (before or after the controlling prompt), the C stimulus was shown. The number of trials per session on the target behaviors were

identical to Experiment I. Experiment II is diagrammed in Figure 1.

In 20-trial session, each subject responded to 4 trials, (two with A1 = B1 and two with A2 = B2). Each instructive feedback stimuli, C1 and C2, was presented twice to each subject in each session. As in Experiment I, each subject had the opportunity to observe the responses of the other group members and the instructive feedback stimuli presented for the up to 16 additional trials. Attention to trials presented to the other students was neither required nor reinforced and no data on attending behavior were collected.

Results

Reliability

For student responses, the percentages of interobserver agreement were calculated using the point-by-point method (as in Experiment I). For probe conditions, interobserver agreement was assessed on 23.8% of the sessions, and in all cases was 100%. In the instructional condition, interobserver agreement was based on 35.7% of the sessions and in all cases was 100%.

Procedural reliability was assessed on 23% of the probe sessions and 35.7% of the instructional sessions. During probes, the procedural reliability on all aspects of the procedure was at 100% on all aspects of the procedure except waiting the correct intertrial interval (99.78; range 96-100%). During instruction, the mean percentage of agreement on procedural fidelity was 100% on all aspects of the technique except for giving praise/ignoring errors (98.8%; range 94-100%).

Acquisition of target relations. The five subjects were all trained to criterion level responding. The number of trials and time were not consistently lower than in Experiment I; these data are presented in Table 4. The error percentage was lower for Experiment II than for Experiment I. In target check probes (4 trials) all students had 100% correct responses. In full probe sessions following training, with intermixed stimuli from all experiments, Ken and Drew had 95.8% correct responses, Barry and Teddy and 91.6%, and Emma had 87.5%.

Acquisition of instructive feedback stimuli. The acquisition of the behaviors (B=C) shown in instructive feedback was low (see Figure 3). Only one student, Teddy, performed at a higher level on the post training probe than in the pretraining probes. Performance on instructive feedback for the other students was near the chance level.

Insert Figure 3 about here

Symmetry and Transitivity. The results of probing for symmetry and transitive relationships are shown in Figure 4. All five students had higher acquisition scores on the post training probes than on the pretraining probes for the symmetrical relationship to the trained behaviors (B=A). Teddy moved from 66% to 83% for the smallest gain of the five; Drew advanced from 17% in pretraining probes to 100% in post training probes. The

transitive relationship (A=C) did not emerge more than might be expected from chance responding except for Emma's performance. She improved from 0% in pretraining to 50% in post training. The four other students either showed a decrease in correct responding or a modest (33%) increase. The symmetrical relationships to instructive feedback (C=B),and the transitivity (C=A) did not show acquisition that could be considered above chance levels.

Discussion

This experiment was initiated to determine whether a history with the technique and a decrease in the number of instructive feedback stimuli were sufficient to allow the emergence of a transitive relationship and the formation of a stimulus class. The results indicate that these modifications were not sufficient to allow the classes to form. However, training was again quite rapid. Thus, the students did not have a large number of exposures to the fractions shown in instructive feedback. Although the number of times these fractions were seen was doubled, the exposure was minimal (i.e., 18 to 28 presentations per stimulus). The redundancies in the stimuli also may have increased the difficulty of the task. Some of the digits in fractions A and C were the same, and the visual configurations were identical (two digits over two digits). Additionally, the students, although not required to do so, were verbally reciting the B (lowest form) stimuli as they pointed to it but were not employing a verbal response to the instructive feedback. Several investigators have questioned whether language mediation has an effect on the formation of stimulus classes (Constantine & Sidman, 1975; Devany, Hayes, & Nelson, 1986; Saunders, 1989). We did not require a language component but speculated whether the subjects' stating the lowest form had an effect. Thus, it was reasoned that if the instructive feedback stimuli were easier (i.e., was the lowest form of the fraction, had fewer digits, involved fewer words in naming) this may result in a greater probability of stimulus class formation. Also, if subjects had a history of previously stating similar fractions during previous experimental conditions, they may be more likely to state the instructive feedback stimuli and thereby assist in the formation of stimulus classes. Experiment III was conducted to test these possibilities.

Experiment III

Experiment III was conducted with the lowest form fraction as instructive feedback stimuli. The stimuli in position B, the one that the students might verbally respond to, was a fraction multiplied by a factor. The students were not required to respond verbally to this stimulus. The specific question asked in Experiment III was similar to that in Experiment II: Could students form equivalence classes in one training series using constant time delay with instructive feedback, conducting target training on only one relationship and introducing one other relationship via instructive feedback? The instructive feedback was the lower form of the fraction, and perhaps easier, than the A or B stimuli. Again, the training was conducted in a group situation in a classroom.

Methods

Subjects and Setting

The subjects and setting for Experiment III were the same used in Experiments I and II.

Materials

The materials differed from those in Experiment II in the content of the fractions taught. The students were trained to identify a fraction that was multiplied by a factor when shown an equal fraction multiplied by a different factor. The instructional feedback stimuli were the lowest forms of the fractions. The stimuli used are shown in Table 2. Reinforcers remained the same.

Instructional Procedures

Constant time delay was used to teach the fractions A1 = B1 and A2 = B2 in Set III (shown in Table 2). Following a correct response (before or after the controlling prompt), the C stimulus was shown on each qualifying trial. The experiment is diagrammed in Figure 1. The number and sequence of presentation of trials to the students remained the same as in Experiments I and II.

In a session of 20 trials, each subject responded to 4 trials, (two with A1 = B1 and two with A2 = B2) and were shown C1 and C2 (fractions in their lowest forms) in the instructive feedback. Each instructive feedback stimuli was presented twice to each subject in each session. As in Experiment I, each subject had the opportunity to observe the responses and the instructive feedback stimuli presented to the other subjects in the group. Attention to trials presented to the other students was neither required nor reinforced and no data on attending behavior were collected.

Results

Reliability

For student responses, the percentages of interobserver agreement were calculated using the point-by-point method. For probe conditions, interobserver agreement was assessed on 46.6% of the sessions, and in all cases was 100%. In the instructional condition, interobserver agreement was based on 72% of the sessions, and was 100% in all cases.

Procedural reliability was assessed on 46.6% of the probe sessions and 72% of the instructional sessions. During probes, the procedural reliability on all aspects of the procedure was at 100% on all aspects of the procedure except for delivering non-committal feedback (99.57; range 90-100%). During instruction, the mean percentage of agreement on procedural fidelity was 100% on all aspects of the technique except showing the correct stimuli (99.8%; range 96-100%).

Acquisition of target relations. The five subjects were again trained to criterion level responding within a minimal number of trials and time in training. The results are shown in Table 3. Emma had a error rate of 0%. The other subjects made some errors but less than 3.5% for any one student. In target checks following training, all students achieved 100% correct responding on the four trials. In full probes following training, Ken was given one day of probes and evidenced poor performance (25% on Tier III target behaviors) and he was returned to training for 6 sessions. Drew and Barry were given a full probe (three

days). Drew performed poorly on the symmetry and transitivity relationships and was returned to training for 6 days and reprobed. Barry performed well on two days of probes but due to a change in his living quarters, he did not comply on the third day. He, too, was returned to training for 6 days. All three of these students performed at 100% for the 6 days and were given 2 days at continuous reinforcement, 2 days at FR2, and 2 days at VR4. Emma and Teddy did not receive extra training. In the probes following all training, four students scored 100% on target behaviors and Ken scored 95.8%.

Acquisition of instructive feedback relations. In probes on instructive feedback (B=C) following all training, Ken and Teddy performed at a 50% correct level with both students performing above their pre-training levels, and the other three students performed at 100% correct level. The results are shown in Figure 4.

Insert Figure 4 about here

Symmetry and Transitivity. Symmetry and transitivity relationships are shown in Figure 4. All students had higher acquisition levels on the symmetrical relationship to training (B=A) than in pretraining probes. Drew, Teddy, and Barry performed at 100%, Emma at 83%, and Ken at 66%. The symmetrical relationship to instructive feedback (C=B) showed similar patterns with Drew and Barry acquiring 100% of these behaviors. The transitive relationship and its symmetrical counterpart (A=C and C=A) were higher in all but one case (C=A) for Ken where it was equal to the pretraining level.

The acquisition levels seemed to indicate the formation of stimulus classes but performances were not perfect; therefore, repeated testing by another individual, the first author, were implemented. Performance stayed at 100% for Drew. Barry made one error on the first day of repeated probes but performed at the 100% correct level on subsequent days. The performance level rose to 100% for Teddy, Emma, and Ken. Ken made one error on the last day of probing in the symmetry of the trained relationship. He had scored at 100% level during the previous session.

Discussion

Moving the lowest form of the fraction (possibly easier) into the position of instructive feedback and the larger (possibly harder) fraction into the target position may have been the modifications that were needed to allow these five students form stimulus classes. The students continued to respond verbally to the B stimulus as well as point to the fraction on the sheet although they were not instructed to do so. They inconsistently verbally responded to the lowest form of the fraction seen in instructive feedback. Although no specific data was collected, it was observed that Emma did not verbalize the instructive feedback, Barry subvocalized the fraction in some of the later sessions. Ken, Teddy, and Drew verbalized the fractions infrequently. Further research is needed to determine whether the language mediator or the smaller fraction in instructive feedback had the greater effect or whether the interaction was critical.

General Discussion

The purpose of this series of experiments was to determine whether stimulus equivalence would emerge as a result of one conditional discrimination training using direct instruction augmented with instructive feedback. Several conclusions are suggested from the results.

First, students were able to form stimulus classes as a result of constant time delay training with the addition of instructive feedback. This effect was shown in the third experiment where the relationship established by instructive feedback was relatively strong. The rapid acquisition of the target behaviors resulted in a minimal number of exposures to the instructive feedback stimuli and relationships. Also, the post test performances on the target relationships were not perfect for most students in Experiment I and II. It was at 100% for three of the students in Experiment III and relatively high for the other two. The difficulty of the target task may have been a factor in Experiments I and II. By modifying the form of the instructive feedback stimuli and possibly by making the target task somewhat more difficult (although the training was still rapid) the students were able to form stimulus classes in a classroom rather than a laboratory setting. It is noteworthy that no special equipment, other than what is generally available in a classroom, was needed.

Efficiency of learning is a consideration in direct instruction studies. Many of the studies completed using stimulus equivalence have used many trials in a trial and error paradigm of conditional discrimination training and concern with the number of errors a subject could make were not a factor in the training. In these experiments, the time to criterion and number of trials was low for all students. The procedure took relatively little time from the student's school day. The error rate in these experiments was low (0 to 9%) with a mean of 2.2%. Lengthy conditional discrimination training may not be necessary to the emergence of stimulus classes given the appropriate selection of material or behaviors to acquire.

Language mediator as an adjunct to the pointing response may have been a large factor. This factor was not controlled. The fractions were in a form that the subjects were familiar with and that they could read in a standard acceptable form. Therefore, even if they had not vocalized the fractions in the instructive feedback, they could have applied a language mediator to the stimulus with subvocalization.

History or experience with the procedure may have affected the results. In other studies using constant time delay, training in the later tiers is generally more rapid than in the earlier tiers (Alig-Cybriwsky, Wolery, & Gast, 1990; Werts, Wolery, Holcombe-Ligon, Vassilaros, & Billings, 1992). During the third experiment, Emma spontaneously reported that she now knew what was expected and that she knew "the back of the cards, too." The procedures should be conducted again with naive students and with the simpler form of the stimulus in the instructive feedback position to determine whether stimulus classes could form without extensive history with the technique or whether it is necessary.

Stimulus equivalence may be a viable adjunct to direct instruction. Instructors should look for the effect and plan teaching sequences to take advantage of it in order to increase the efficiency of instruction. Informal analysis indicates that many fewer trials of instruction

were needed in this near errorless instructional technique as compared to traditional conditional discrimination training. Clearly, further research is needed to merge the phenomenon of stimulus equivalence and direct classroom instruction.

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Table 1

Descriptions of Subjects

Name	Gender	Age	IQ[1]	Years of Special Education
Emma	F	12-11	111	2
Teddy	M	14-8	83	4
Barry	M	14-0	117	4
Ken	M	14-3	95	1
Drew	M	12-10	107	3

1 WISC-R scores all obtained from school records. The tests were given by the school's psychologists.

Table 2

Stimuli used in Experiments I, II, and III

	Stimuli			
Experiment	A	B	C	D[1]
Experiment I	16/20	4/5	48/60	52/65
	8/28	2/7	24/84	26/91
Experiment II	36/60	3/5	39/65	--
	21/27	7/9	28/36	--
Experiment III	78/91	72/84	6/7	--
	30/48	20/32	5/8	--

1 "D" stimuli in Experiments II and III were dropped. See text for explanation.

Table 3

Efficiency data

Subject	Number of Trials	Time to Criterion	Percent of Errors
Experiment I			
Emma	44	47:37	0
Teddy	44	46:15	9
Barry	52	50:39	6
Ken	32	29:15	0
Drew	48	50:26	4
Experiment II			
Emma	36	35:44	0
Teddy	56	47:53	3.5
Barry	44	43:37	0
Ken	32	34:12	0
Drew	56	47:33	0
Experiment III			
Emma	30	32:57	0
Teddy	58	46:54	3.4
Barry[1]	74	55:13	2.7
Ken[1]	66	50:16	1.5
Drew[1]	73	49:15	1.3

1 These students were exposed to an additional 24 trials each due to poor probe performance following training. The additional trials were at 100% correct responding for all three students.

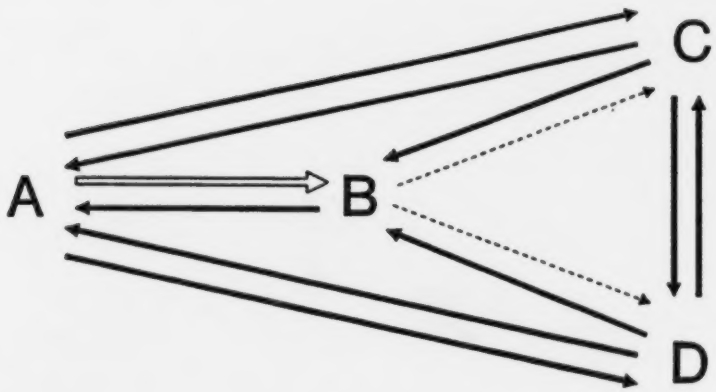
Figure Captions

Fig. 1. Diagrammatic representation of Experiment I (top) and Experiments II and III (bottom). The hollow line represents the trained relationship. The dashed line is the relationship established by instructive feedback. The solid lines were expected to be established through symmetry and transitivity.

Fig. 2. Acquisition of the relationships between the stimuli in Experiment I. The first graph shows the level of correct responding to the instructive feedback relationship by the five students. The other graphs show the level of correct responding to the symmetry and transitive relationships during pretraining and post-training probes.

Fig. 3. Acquisition of the relationships between the stimuli in Experiment II. The first graph shows the level of correct responding to the instructive feedback relationship by the five students. The other graphs show the level of correct responding to the symmetry and transitive relationships during pretraining and post-training probes.

Fig. 4. Acquisition of the relationships between the stimuli in Experiment III. The first graph shows the level of correct responding to the instructive feedback relationship by the five students. The other graphs show the level of correct responding to the symmetry and transitive relationships during pretraining and post-training probes. Repeated testing is shown as additional bars in each relationship.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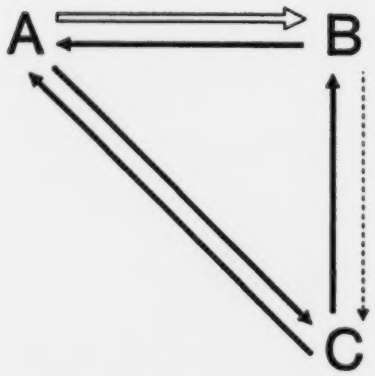
B
D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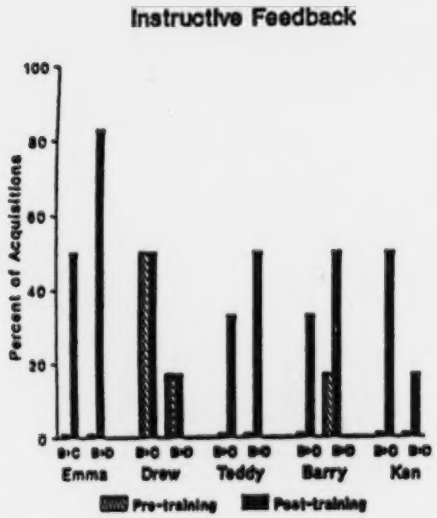
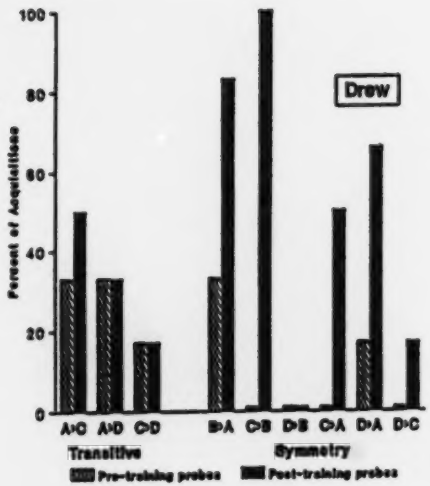
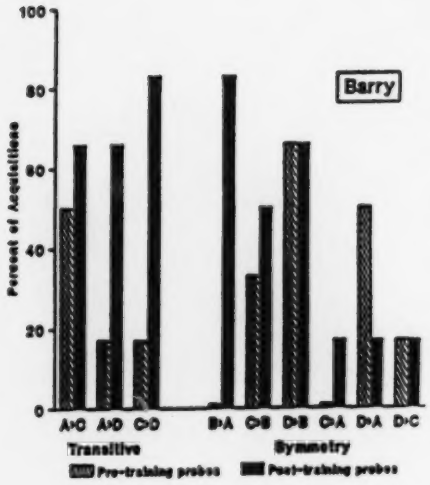
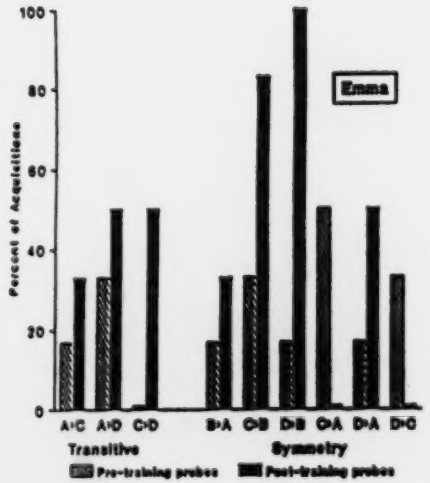
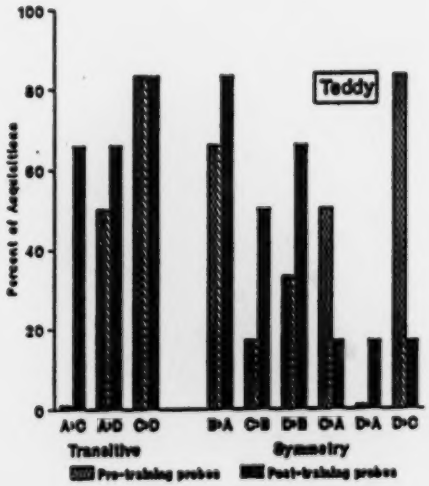
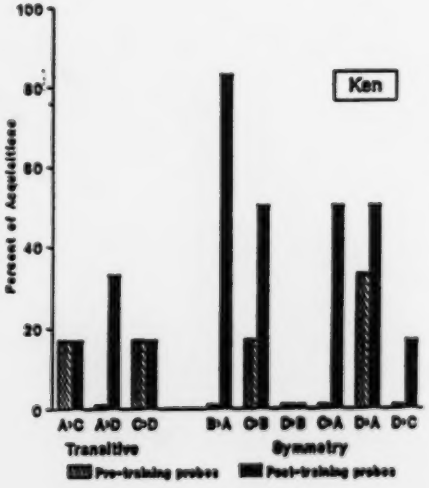

Instructive Feedback
Percent of Acquisitions
100
80
60
40
20
0
B>C B>D
Emma
Drew
Teddy
Barry
Ken
Pre-training
Post-training

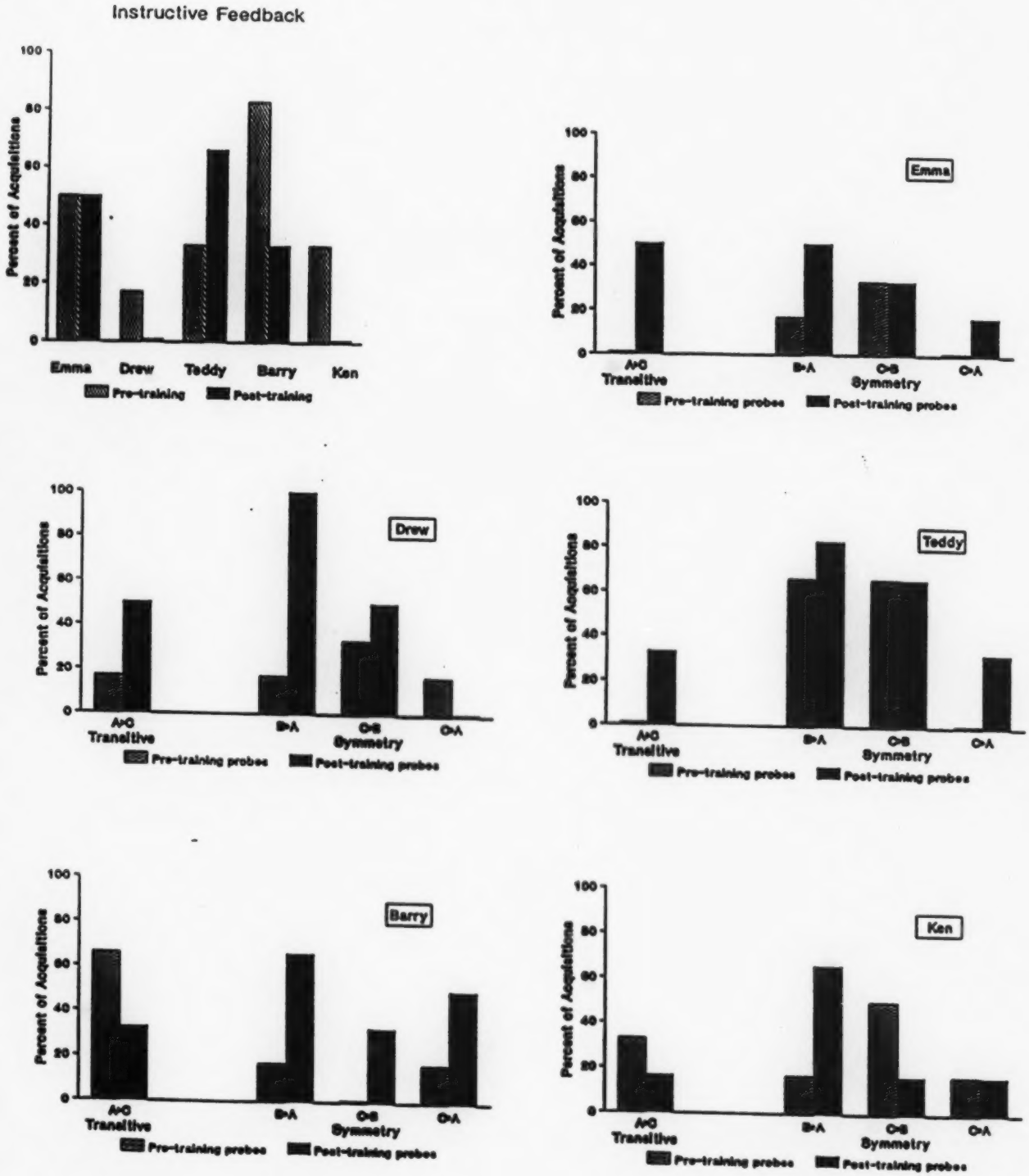

Drew
Percent of Acquisitions
A>C A>D C>D
Transitive
B>A C>B D>B C>A D>A D>C
Symmetry
Pre-training probes
Post-training probes

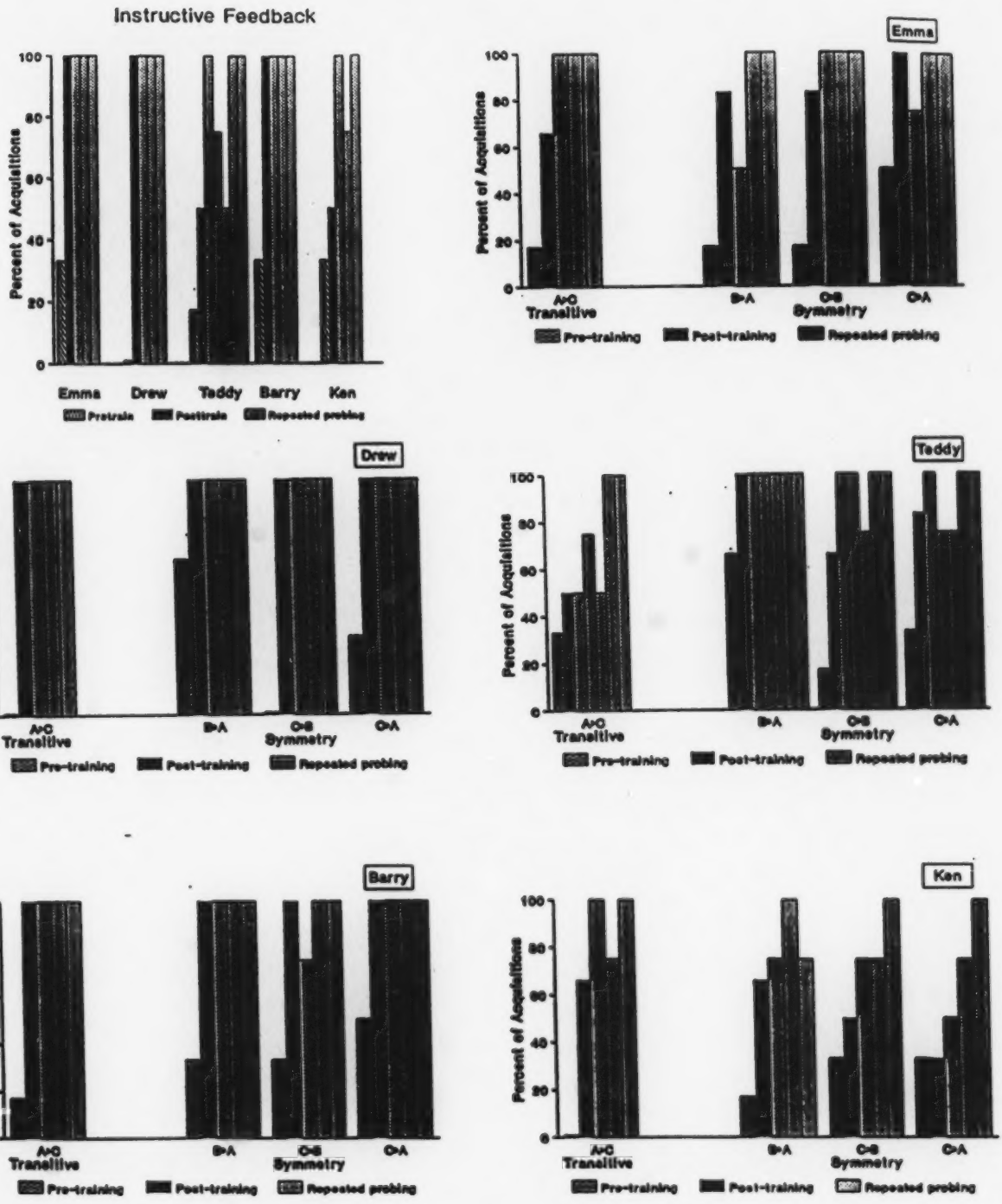

Barry
Percent of Acquisitions
A>C A>D C>D
Transitive
B>A C>B D>B C>A D>A D>C
Symmetry
Pre-training probes
Post-training probes


Emma
Percent of Acquisitions
A>C A>D C>D
Transitive
B>A C>B D>B C>A D>A D>C
Symmetry
Pre-training probes
Post-training probes


Teddy
Percent of Acquisitions
A>C A>D C>D
Transitive
B>A C>B D>B C>A D>A D>C
Symmetry
Pre-training probes
Post-training probes


Ken
Percent of Acquisitions
A>C A>D C>D
Transitive
B>A C>B D>B C>A D>A D>C
Symmetry
Pre-training probes
Post-training probes


Instructive Feedback
Percent of Acquisitions
100
80
60
40
20
0
Emma
Drew
Teddy
Barry
Ken
Pre-training
Post-training
Emma
Drew
Teddy
Barry
Ken
A>C
Transitive
B>A
C>B
Symmetry
C>A
Pre-training probes
Post-training probes


Instructive Feedback
Percent of Acquisitions
100
80
60
40
20
0
Emma
Drew
Teddy
Barry
Ken
Pretrain
Posttrain
Repeated probing
Emma
A>C
Transitive
B>A
C>B
Symmetry
C>A
Pre-training
Post-training
Repeated probing
Drew
Teddy
Barry
Ken